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Polar Spots on Mars observed with the Colour and Stereo Surface Imaging System (CaSSIS).

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Abstract

Polar sublimation-driven processes, seasonal fans and dark spots, are being investigated using the Colour and Stereo Surface Imaging System (CaSSIS) to understand their origin and composition.

1. Introduction

Many observations of the polar and circum-polar Martian surface have led to a better understanding of the processes occurring there at different seasons of the Martian year. A conceptual model was proposed by [1] for the formation of polar spots, dark fans and araneiform terrain in the southern hemisphere, which is in agreement with observations thus far [2]. Those features would appear in certain regions where approximatively 1 m of CO_2 ice deposited during winter and becomes an impermeable translucent slab after cleaning processes in Spring. Insolation heats the substrate, leading to CO_2 ice sublimation at the slab's base which results in a pressure rise. The slab weakens and then ruptures locally to release the pressure, forming jets of CO_2 gas carrying sand and dust, which result in fans and dark spots. The gas flow below the ice erodes the substrate to form araneiform beneath a spot (fig.4 in [1]).
The Colour and Stereo Surface Imaging System (CaSSIS) [3] is the high-resolution imager onboard ESA's ExoMars Trace Gas Orbiter (TGO), built at the University of Bern. The goals of CaSSIS are to analyse and image surface features, map regions of trace gas origination, search for possible new landing sites candidates and certify their safety. Its high signal-to-noise ratio and the non-Sun synchronous orbit of TGO allow CaSSIS to acquire high quality images of the surface at various local times during the entire year. Although TGO's orbit inclination of 74° prevents the observation of the poles, circumpolar processes occurring in a 70-74° latitude band can be studied in great detail.

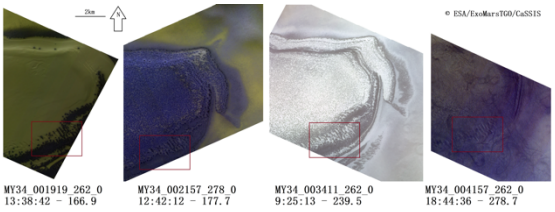

Figure 1: Time evolution of blue spots on a layered plateau in an unnamed crater located between Hutton and Burroughs craters (72°S , 110°E).

Similar spots and fans, but with a clear difference of colour, are observed in a single CaSSIS image (Fig. 2) taken near Sisyphy Montes at the end of the Southern winter. The reasons for the observed differences are still unknown. Based on their similarities with the other well-known sublimation-driven features, they seem to also fall into this category and originate from jet-like processes. A topography-related deposition could also be considered based on the observed density, though spots and fans are present on the smoother areas in smaller concentrations. Several questions are raised by this observation: Is this behaviour recurrent in this area? If yes, is there a common origin between the dark spots covered in the literature and these features? Can a temporal evolution be established, and a formation mechanism be theorised based on what is observed? If an evolution is established, what is the interpretation of the observed colours, and are they related to composition?

Figure 2: (Top) CaSSIS image taken on May 7th 2018 near Sisyphy Montes (72°S , 341°E) at a solar longitude of 171.6

2. Results and discussion

Eight reflectance profiles were taken across all four CaSSIS images presented in Fig. 1. The example of profile #8 and its variation through the images is shown in Fig. 3. The effects of the darker spots on the reflectance profiles are generally obvious (long-period wells on red and blue curves in both filters, on black and green curves only in NIR filter).

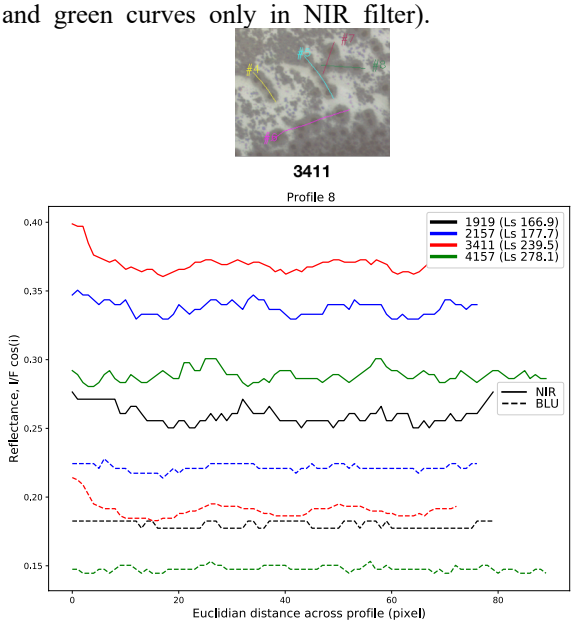

Figure 3: (Top) Profiles in CaSSIS images located at 72°S and 110°E. (Bottom) Reflectance values for various Ls acquisitions and NIR/BLU CaSSIS filters.

A clear increase of reflectance is seen from winter to spring, then in summer the reflectance decreases as the ice sublimates. The most impressive change is between the black and blue profiles which are taken approximately at the same period (L_s 167°/178° with different incidence angles) and the reflectance values are affected by a factor of 1.2.

The reflectance observed between features in Fig. 2 shows that the yellow and orange PAN's values decrease while RED-NIR's increase or stay stable. Green features show similar PAN and NIR downward trend and the RED filter values increasing. One question that comes to mind is whether these fans and spots originate from the same process. A possible evolution can be theorised from the CaSSIS observation, in which the first step is the deposition of black fans on top of the ice. These fans then experience a change of colour at their centre, the dark contour disappearing gradually so that only a coloured spot remains visible for some time before fading away entirely. This behaviour has not yet been explained experimentally nor theoretically and is still under investigation.

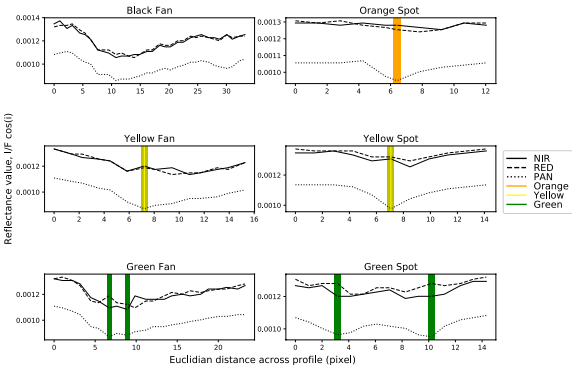

Figure 4: Reflectance profiles across some spots and fans observed in Fig.2.

3. Future observations

So far only one CaSSIS image has shown the behaviours shown in Figs. 2 and 4 **and new observations of** the same area will help understand the reason for these peculiar features. Comparison with other instruments (CRISM, HiRISE) will provide better insight. Experimental work is planned to better understand the relationship between colour and composition.

Acknowledgements

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